

INSTITUUT VOOR PLANTENZIEKTENKUNDIG ONDERZOEK
WAGENINGEN, NEDERLAND
DIRECTEUR: Dr. J. G. TEN HOUTEN

MEDEDELING No 198

EXPERIENCES WITH AERIAL SPRAYING AGAINST
POTATO LATE BLIGHT IN THE NETHERLANDS

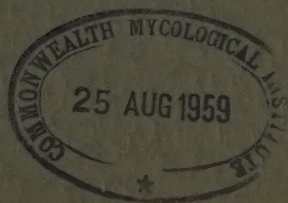
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Experiences with aerial spraying against potato late blight in the Netherlands

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In investigating the possibilities of the use of aircraft in agriculture, the control of potato late blight caused by the fungus *Phytophthora infestans* (Mont.) de Bary, has been one of the most important problems to solve. Due to the prevention of wheel damage to the crop and the possibility to spray when the soil is too wet to use ground equipment, aerial spraying seemed very suitable for this purpose. Spraying with ground equipment was already very successful when in 1951 the first trial with an airplane was carried out. Therefore an effect of aerial spraying at least equal to spraying by ground equipment was required.

As the spraying against this disease is preventive, i.e. before an outbreak of late blight, the application of the fungicides must be repeated several times. Generally consumption and ware potatoes are treated 4-7 times, depending on the susceptibility of the variety; industrial potatoes, which are stored a short time only and are mostly less susceptible, 1-3 times. Weather conditions have great influence on the development of the disease. The Royal Netherlands Meteorological Institute warns by broadcast when and where the temperature and humidity are favourable for infection. At that time the plants must be provided with a protective amount of fungicide.

The most important fungicides which are effective against this disease are the copper-compounds. If early spraying is required, carbamates are recommended for the first two treatments in order to prevent a possible yield depression due to copper damage on the leaves. However, as the coppercompounds protect the tubers better against infection by the fungus, these are advised by the Nether-

lands Plant Protection Service to be used after the first of July.

One of the differences between aerial and ground spraying is the amount of liquid applied per hectare. On account of economical reasons the amount of spray liquid per ha applied by airplane is kept as low as possible (maximal 45 l per ha); low- and high volume spraying by ground equipment is carried out in 120-800 l per ha. Because the same amounts of fungicide have to be used high concentrations must be prepared for aerial spraying. For instance, when using copperoxychloride (50 % Cu), 7-10 kg per ha have to be applied; zineb is used in lower dosages, namely 3-5 kg per ha. No special formulations of fungicides for aerial spraying are in use in our country. The chemicals must be very thoroughly mixed with water to obtain a homogenous suspension.

Investigation methods in field trials

To diminish the number of factors influencing the results, the tests are carried out on one field, planted with a potato variety susceptible to late blight. Preferably the objects have a width of at least twice the swath width of the equipment, because at repeated treatments slight deviations may occur in coverage of the crop as caused by wind influence, different flying heights etc. The amount of spray liquid used is checked by measuring the amount of liquid in the spray-tank before and after spraying. In doing so a possible settling of the suspension can be checked also. Glass plates are placed in the crop at the height of the tops of the plants in a row at right angles to the line of flight. By means of counting the number of

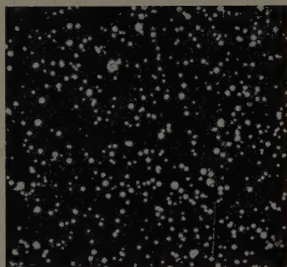
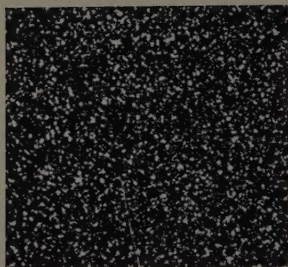


Fig. 1. Left: Ground equipment; low volume 180 l/ha. Right: Aerial spraying, 40 l/ha.

droplets per cm^2 , measuring the droplet size and analyzing the residue on the glass plates the distribution of the spray is determined. If copper compounds are applied leaves of the sprayed plants are gathered, which after drying are treated with ferric ferrous cyanide and glacial acetic according to the method of *Blodgett & Mader* (1). The prints, made in this way, show the spray-pattern on the leaves. Also this method can be used to establish the redistribution of the residue under influence of dew or rain.

The quantitative determinations of the residues on the leaves are made by colourimetric methods. Copper residues are coloured by the method of *Martin* (2). Punched parts of the leaves are washed off with sulphuric acid; by adding ammoniacal ammonium-citrate and a solution of bis-cyclohexanone oxalyldihydrazone a blue colouring occurs if copper-ions are present. The optical density of the colour is determined by a spectrophotometer.

To analyse residues of dithiocarbamates a suitable colourimetric method is also available (*Kerssen and Riepma*, 3). To obtain a yellow coloured solution, sodium-hydroxide, sodium pyrophosphate and coppersulfate are added.

Analyses of leaf samples from different layers of the plants are used to establish the penetration of the spray into the crop. Before the next treatment takes place, samples of leaves are taken to determine the amount of residue still present from the last spraying. To check the effect of the treatments the development of the disease on the foliage is estimated at different dates. When lifting yield determinations are made in different plots in the field. Also the percentage of the

tubers infected by the fungus is established.

Results of the trials

As in our country Piper Super Cubs are generally preferred for aerial spraying, this type of airplane was used in most of the comparative trials. The planes are provided with Spraying system's diaphragm Tee-jet nozzles. The total number of nozzles varies from 24 to 47. The orifices D6 and D8 and the cores 25 and 45 were used. The droplet size produced by this type of nozzle is larger than the droplet sizes of low-volume ground sprayers (fig. 1). As the amount of liquid per ha applied by airplane is 30–45 l against 120–800 l when applied by ground sprayers, the number of droplets per cm^2 in aerial spray residues is less. The dried droplets on the potato leaves are more evenly shaped than on the glass plates as can be seen by microscope (fig. 2); so they cover a larger surface than on the glass plates. It is known that copper spots are active outside the area which is seen to be occupied. (*Horsfall*, 4 and *Morgan*, 5). This is important as it enables the coarse droplets of the aerial spraying residues to prevent an infection on the fungus.

The dried residues on the leaves are easily spread by dew or rain as may be seen in fig. 3. Thus the leaf will be more evenly covered with little particles of the active ingredient. Most of the residue is found on the upper surface of the leaves, in either case of aerial and ground spraying. Sometimes a few droplets settle on the underside, but these can be of no importance for the control.

The amount of fungicide which reaches the middle and underlayers of the plants de-

depends of course on the density of the foliage. An example of the analyses of leaves in comparative spraying with copperoxychloride (50 % Cu) is given in table 1. In the second column of this table the remaining amounts after rainfall are given.

The analyses of the leaves show that there is no significant difference in penetration of the spray into the crop by both ways of treatment.

Several compounds have been tested in our trials as for instance different brands of copperoxychlorides, copperoxides and the so-called "colloidal coppers". The last ones seemed to be very suitable for aerial spraying, because they are sold as a paste, which is easier to mix in high concentrations than the

wettable powders. Unfortunately our experiments showed that most of these preparations had a tendency to be less effective against the disease (*ten Houten and Kerssen, 6*). Sprayings with a decreased dosage of copperoxychloride ($\frac{2}{3}$ of the normal dosage) and an extra amount of sticker gave an increase in tuber infection. In our first trial with zineb we had some difficulties in spraying this material by airplane. Quite a lot of the zineb did not reach the crop (*Kerssen, 7*). By better mixing and using an improved product in later years this problem was solved.

All our experiments showed that both aerial and ground spraying gave the same control of the disease, provided that the treatment was carried out on the same date with a spray, which covered the crop uniformly and when using equal amounts of the same chemical per ha. Special care must be taken that a good overlap of the runs is obtained. The crop must be evenly covered so no strips may be left untreated.

The wheel damage caused by the ground sprayers varied from 2.3 to 5.2%, depending a.o. on the swath width of the equipment. We found that a loss in yield of about 4 % is common when using low-volume sprayers with a swath width of 10 m.

Results in practice

As soon as the results of our first trials were known, the spraying companies started to spray in practice. After six years of experience the potato area treated by aircraft is still increasing. For the last 3 years about

Fig. 2. Copperoxychloride residue on potato leaves



TABLE 1. Copper analyses of leaves. Average amount Cu in g from 50 samples of 2.5 cm²

		Immediately after spraying			After raining-off		
		2-7	16-7	29-7	16-7	29-7	6-8
Low volume sprayer 180 l/ha	upper	34.4	47.3	34.1	2.5	1.2	16.3
	middle	23.1	34.9	22.2	2.5	2.8	11.6
	bottom	4.4	5.1	7.6	3.5	4.8	3.9
Aerial spraying, 40 l/ha	upper	38.7	48.9	40.8	0.3	0.3	12.7
	middle	39	28.9	7.7	0.9	2.5	11.8
	bottom	2.7	5.9	4.9	4.2	7.3	2.8



Fig. 3. Redistribution by rain of aerial spraying residue 40 l/ha.

40 % of aerial spraying in the Netherlands consisted of the control of late blight. Piper Super Cubs as well as different types of helicopters (Djinn, Hiller and Kolibrie) have

been doing this work with good results. The costs of treatment by aircraft are higher than spraying by ground equipment but because there is no loss in yield caused by wheel damage the farmer will often favour aerial spraying.

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